Remarks

Claims 26-57 are rejected. Claims 26-57 remain in the application. Claims 26-35 and 37-40 have been amended.

Claims 26-35 and 37-40 have been amended in order to avoid invoking 35 U.S.C. 112, sixth paragraph. In particular, all instances of phrases such as --the steps of--, and -- the step of-- have been deleted. Applicant wishes to note for the record that the amendments are not intended to be narrowing, nor are the amendments being made for a reason related substantially to patentability. Applicant respectfully submits that no new matter has been added in the amendments.

Claim Rejections – 35 USC 102

Claims 26-28, 31, 32, 36-39, 41, 43-46, 49, 51, and 53-57 are rejected under 35 U.S.C. 102(b) as being clearly anticipated by Borisov et al. (Spectrochimica acta).

Referring to independent claim 26, Applicant discloses and claims a method of compositional analysis of one or more components comprising the steps of (emphasis mine):

(a) directing a pulse of laser radiation at a target of the heterogeneous material to ablate an amount thereof, and to form an ablation crater having a depth;

(b) determining the concentration of one or more selected components in the heterogeneous material ablated from the target;

(c) **measuring in situ the depth of the ablation crater** other than in dependence upon time gated imaging data of the directed pulse of laser radiation, and

(d) determining a composition of the heterogeneous material at the depth.

The limitations of claim 26 define a method of compositional analysis wherein the ablation crater depth is measured ***in-situ*** using an optical sensing apparatus – defined by the highlighted limitation of step (c). In other words, the crater depth is measured ***in its original place***, i.e. a workpiece under investigation is not removed after ablating an amount of material and determining the concentration of one or more selected components for determining the crater depth using, for example, another apparatus. The combined action of ablation, determination of a concentration, and ***in situ*** crater depth measurement using a same apparatus immediately provides highly accurate information about a sample composition at a known depth.

Cited reference Borisov et al. teaches repetitive laser ablation using an ablation cell, page 1694. The ablation is performed at the junction of two flat glass plates, page 1695. Following ablation in the ablation cell, the sample is removed from the ablation cell and the glass plates are separated, revealing the ablation crater in cross-section, page 1695. A white-light interferometric microscope is then used to examine crater parameters such as diameter, depth, and volume based on the cross-section, page 1695. As is evident, Borisov et al. do not teach ***in situ*** measurement of the crater depth but teach laser ablation at a first location – ablation cell - and measurement of crater parameters at a second location– microscope – as well as transfer and preparation of the sample – separation of the glass plates - prior to the measurement of the crater parameters. Applicant respectfully submits that the method of compositional analysis as defined by the limitations of claim 26 is novel in providing immediate information about a sample composition at a known depth and is not anticipated by Borisov et al.

Referring to dependent claim 27, Applicant discloses and claims a method of compositional analysis as defined by the limitations of claim 26 and further comprising the limitation in step c) that the measuring of the depth is performed based on sensing of a

beam of light directed at the target and other than the pulse of laser radiation. This additional limitation defines use of an optical system such as an interferometer providing and sensing a beam of light other than the laser pulse for measuring the crater depth. Sensing a beam of light other than the laser pulse for measuring the depth of the crater is highly advantageous for the ***in situ*** measurement by providing immediate and accurate information about the depth at a point of the crater bottom. In contrast, Borisov et al. teach use of a white-light interferometric microscope simultaneously measuring a **surface area** of 500 x 500 μm^2 and a **depth** of 100 μm for revealing details of crater morphology. Applicant respectfully submits that the method of compositional analysis as defined by the limitations of claim 27 is not anticipated by Borisov et al. Furthermore, claim 27 depends on a claim that is believed to be allowable and as such is allowable.

Referring to dependent claim 28, Applicant discloses and claims a method for determining a compositional profile of a heterogeneous material as a function of the depth by repeating at least one of the steps (a) to (d). By repeating the combined action of ablation, determination of a concentration, and crater depth measurement, information about sample composition and depth are immediately obtained with each laser pulse resulting in a sequence of measurements as a function of increasing crater depth. The method as defined by the limitations of claim 28 is highly advantageous by providing a fast and highly accurate process for determining a compositional profile of a heterogeneous material. The depth profiling capability of the present method is highly useful in numerous applications, for example, in the pharmaceutical industry for assessing blend uniformity in tablets of a drug, lubricant, or other components, or the evaluation of coating homogeneity and thickness across the surface of the tablet.

Borisov et al. teach assessing the depth only after typically hundreds of laser pulses. The method taught by Borisov et al. is time consuming and is impractical for real time evaluation of the crater depth during a sequence of laser pulses. Furthermore, this method

does not produce an accurate representation of the composition as a function of the crater depth, since the ablation efficiency usually changes as a function of depth, i.e. it is, for example, not possible to measure the depth after 200 laser pulses and determine a depth after 100 laser pulses using interpolation. On the other hand, applying the method taught by Borisov et al. after each laser pulse in order to obtain a more accurate depth profile is impractical to implement due to its complexity requiring removing the sample from the ablation chamber, separating the two sample portions for depth measurement, providing the sample portions to the interferometric microscope, measuring the depth, removing the sample portions, combining the sample portions with an accuracy in the nanometer range, providing the sample to the ablation chamber and realigning the ablation crater with the pulsed laser. Considering the dimensions in the μm range of an ablation crater, it is highly unlikely to realign the ablation crater with the pulsed laser in three dimensions after the workpiece has been removed for depth analysis and reaffixed in the ablation chamber with sufficient accuracy in order to ensure that ablation and sampling produced by successive laser pulses follows a substantially straight line, in particular, when considering a repetition of a hundred or more times.

Therefore, Applicant respectfully submits that the method of compositional analysis as defined by the limitations of claim 28 is highly inventive and not anticipated by the teachings of Borisov et al. Furthermore, claim 28 depends on a claim that is believed to be allowable and as such is allowable.

Referring to dependent claim 31, Applicant discloses and claims a method of compositional analysis as defined by the limitations of claim 28 and further comprising the limitations in step c) of measuring the depth of the ablation crater at a plurality of points thereacross and generating a depth profile of the ablation crater. To perform a reliable depth profile analysis, it is important to ensure a controlled and reproducible ablation rate and a well-characterized ablation volume. The ablation is preferably the same for each laser

pulse in terms of radial distribution of the ablated depth. In order to obtain this result, the spatial characteristics of the laser beam are controlled and the laser is preferably stable from pulse to pulse. In particular, to achieve a good depth resolution, all portions of the laser beam throughout its cross-section sample the material at approximately to a same depth. This condition is difficult to satisfy with a near-Gaussian laser beam profile, resulting in cone-shaped craters. Therefore, it is often preferable to tailor the radial distribution of energy in the laser beam to produce a crater with flat bottom and steep walls. Determining a depth profile of the ablation crater as defined by the limitations of claim 31 is highly advantageous by providing necessary information about the depth profile for tailoring the radial distribution of the energy in the laser beam. As discussed above with respect to claim 28, the method taught by Borisov et al. is impractical for repeatedly generating the depth profile of the ablation crater after each laser pulse or after a predetermined number of laser pulses. In order to be able to use the depth profile information for tailoring the radial distribution of the energy in the laser beam it is necessary to obtain this information ***in situ*** as defined by the limitation of claim 31.

Therefore, Applicant respectfully submits that the method of compositional analysis defined by the limitations of claim 31 is highly inventive and not anticipated by the teachings of Borisov et al. Furthermore, claim 31 depends on a claim that is believed to be allowable and as such is allowable.

Dependent claim 32 defines the method of compositional analysis of claim 31 comprising the further limitations of repeating the generation of the depth profile at a plurality of depths of the ablation crater and generating an evolution of the depth profile. The method defined by the limitations of claim 32 is highly beneficial for determining a compositional profile of a heterogeneous material. For example, discontinuities observed in the evolution of the depth profile are indicating sudden removal of large particles such as large powder particles in the above example of the tablet. As discussed above with respect to claim 31, Borisov et al. do not teach anything similar to the highly inventive steps as defined by the

limitations of claim 32. Furthermore, claim 32 depends on a claim that is believed to be allowable and as such is allowable.

Regarding claim 36, Applicant discloses and claims a method of compositional analysis as defined by the limitations of claim 26 and further comprising the limitation of determining the concentration using selected spectrochemical analysis techniques. The selected spectrochemical analysis techniques defined by the limitations of claim 36 are preferred for the implementation in the method of composition analysis by allowing more flexibility in terms of sample shape, size, and even movement since the sample does not have to be enclosed in an ablation chamber. Borisov et al. teach only use of inductively coupled plasma mass spectrometry (ICP-MS) which requires use of an ablation chamber. As is evident, ICP-MS is substantially reducing flexibility and, therefore, is definitely not an analysis technique of choice for use in the method of compositional analysis according to the present invention. Applicant respectfully submits that the method of compositional analysis defined by the limitations of claim 36 is highly inventive and not anticipated by the teachings of Borisov et al. Furthermore, claim 36 depends on a claim that is believed to be allowable and as such is allowable.

Dependent claim 37 defines the method of compositional analysis of claim 26 comprising the further limitation of using a technique selected from confocal microscopy, laser triangulation, and interferometry for measuring the depth of the ablation crater. Use of one of these optical techniques enables highly accurate ***in situ*** depth measurements of the ablation crater as defined by the limitation of step c) in claim 26. Applicant respectfully submits that Borisov et al. do not teach use of a white-light interferometric microscope for ***in situ*** depth measurement but to examine crater parameters such as diameter, depth, and volume based on the cross-section generated by separating the sample, as was argued with reference to claim 26. Accordingly, claim 37, which depends from believed allowable claim 26, is also believed allowable.

Regarding dependent claim 38, Applicant discloses and claims the method of compositional analysis of claim 37 comprising the further limitation defining the steps of an interferometric depth measurement. The same arguments as presented above with respect to claims 26 and 37 apply here. Accordingly, claim 38, which depends from believed allowable claim 37, is also believed allowable.

Regarding dependent claim 39, Applicant discloses and claims the method of compositional analysis of claim 38 comprising the further limitation defining depth measurement at another location for generating a depth profile of the ablation crater. To achieve a good depth resolution of the compositional depth profile, all portions of the laser beam throughout its cross-section sample the material at approximately to a same depth. The method as defined by the limitations of claim 39 is highly advantageous by providing ***in situ*** measurement of the depth profile of the ablation crater enabling the determination of the depth resolution of the compositional depth profile. However, this information is only useful when obtained through ***in situ*** measurement. Furthermore, the ***in situ*** measurement of the depth profile of the ablation crater enables tailoring of the radial distribution of energy in the laser beam to produce a crater with flat bottom and steep walls in order to ensure good depth resolution of the compositional depth profile. Applicant respectfully submits that Borisov et al. do not teach ***in situ*** measurement of the depth profile of the ablation crater, as argued above with respect to claims 26 and 37. Accordingly, claim 39, which depends from believed allowable claim 38, is also believed allowable.

Dependent claim 41 defines the method of compositional analysis of claim 38 comprising the further limitation of the short coherence light propagating colinearly with the laser radiation. Applicant respectfully submits that Borisov et al. do not teach this limitation, but using a white-light interferometric microscope for examining the cross-section of the

ablation crater after separating the sample – glass plates, page 1695. Therefore, the light of the interferometric microscope in Borisov's method is oriented approximately perpendicular to the orientation of the laser radiation used for generating the ablation crater. Having the short coherence light propagating colinearly with the laser radiation enables depth measurement along the direction of the depth axis resulting in depth measurements of substantially higher accuracy compared to measurements having the short coherence light oriented in other directions. Accordingly, claim 41, which depends from believed allowable claim 38, is also believed allowable.

Regarding claims 43 to 46, Applicant discloses and claims an apparatus for compositional analysis corresponding to method claims 26, 27, 36, and 37. Apparatus claims 43 to 46 have been rejected by the examiner for the same reasons as the method claims. Therefore, the same arguments apply here *mutatis mutandis*.

Regarding claim 49, Applicant discloses and claims the optical device defined by the limitations of claim 43 further comprising the limitation defining a dual beam measuring system for simultaneous measurement of depth at two **points** on the sample surface. Applicant respectfully submits that Borisov et al. do not teach a system for **point** measurements of the crater depth, but for simultaneously measuring a **surface area** of 500 x 500 μm^2 and a **depth** of 100 μm for revealing details of crater morphology. Accordingly, claim 49, which depends from believed allowable claim 43, is also believed allowable.

Regarding claim 51, Applicant discloses and claims an apparatus for compositional analysis corresponding to method claim 41. Apparatus claim 51 has been rejected by the examiner for the same reasons as the method claim. Therefore, the same arguments apply here *mutatis mutandis*.

Regarding dependent claims 53 and 54, Applicant discloses and claims the apparatus defined by the limitations of claim 43 further comprising limitations defining means for generating a laser beam of substantially uniform radial distribution. To achieve a good depth resolution it is desired that all portions of the laser beam throughout its cross-section sample the material at approximately to a same depth. This condition is difficult to satisfy with a near-Gaussian laser beam profile, resulting in cone-shaped craters. Therefore, it is preferable to tailor the radial distribution of energy in the laser beam to produce a crater with flat bottom and steep walls using the apparatus defined by the limitations of claims 53 or 54. Applicant respectfully submits that Borisov et al. do not teach means for tailoring the radial distribution of energy in the laser beam. Accordingly, claims 53 and 54, which depend from believed allowable claim 43, are also believed allowable.

Regarding claims 55 to 57, Applicant discloses and claims an apparatus for compositional analysis corresponding to method claims 26 and 28. Apparatus claims 55 to 57 have been rejected by the examiner for the same reasons as the method claims. Therefore, the same arguments apply here *mutatis mutandis*.

Claim Rejections – 35 USC 103

Claims 29, 30, 33-35, and 48 are rejected under 35 U.S.C. 103(a) as being unpatentable over Borisov et al. (Spectrochimica acta).

Regarding dependent claim 29, Applicant discloses and claims a method for determining a compositional profile as defined by the limitations of claim 28 further comprising the limitation shifting the target to another location across the heterogeneous material and repeating the steps defined by the limitation of claims 28 and 29. By repeating the

combined action of ablation, determination of a concentration, and crater depth measurement, as defined in claim 28, information about sample composition and depth are immediately obtained with each laser pulse resulting in a sequence of measurements as a function of increasing crater depth. Repeating this process for different locations across the heterogeneous material, as defined by the limitations of claims 29 and 33, results in a three dimensional matrix of information about sample composition as a function of location and depth. This information is then used to determine a three dimensional compositional profile of the heterogeneous material as defined by the limitations of dependent claim 30, 34, and 35. The method as defined by the limitations of claims 29, 30, and 33-35 is highly advantageous by providing a process for determining a three dimensional compositional profile of a heterogeneous material that is fast and highly accurate. Applicant respectfully submits that the method for determining a compositional profile is not obvious in light of the teachings of Borisov et al. The method taught by Borisov et al. is impractical for determining a three dimensional compositional depth profile of the heterogeneous material. In order to obtain three dimensional information about sample composition Borisov's method requires the steps of: removing the sample from the ablation chamber, separating the sample portions for depth measurement, providing the sample portions to the interferometric microscope, performing depth measurement, removing the sample portion from the interferometric microscope, combining the sample portions with an accuracy in the nanometer range, providing the combined sample to the ablation chamber and adjusting the position in three dimensions with an accuracy in the nanometer range. As is evident to one of skill in the art, determining a three dimensional compositional profile using Borisov's teachings would not only require an unacceptable amount of time but would be inherently inaccurate due to the process steps involved. In other words, Borisov et al. teach away from attempting to obtain a three dimensional compositional profile. Accordingly, claims 29, 30, and 33-35, which depend from believed allowable claim 28, are also believed allowable.

Dependent claim 48 defines an apparatus for implementing the method of compositional

analysis as defined by method claim 29. Apparatus claim 48 has been rejected by the examiner for the same reasons as the method claim. Therefore, the same arguments apply here *mutatis mutandis*.

Claims 40 and 50 are rejected under 35 U.S.C. 103(a) as being unpatentable over Borisov et al. (Spectrochimica acta) as applied to claims 29, 30, 33-35, and 48 above, and further in view of Gong et al. (US Patent 6,643,027).

Regarding dependent claim 40 and 50, Applicant respectfully submits that the method for compositional analysis as defined by the limitations of dependent claim 40 and the corresponding apparatus as defined by the limitations of dependent claim 50 are not obvious in light of the teachings of Borisov et al. and Gong et al. Replacing the interferometer of Borisov et al. with the differential interferometer of Gong et al. does not result in ***in situ*** depth measurement of the ablation crater and an optical device therefore. It still requires the complex process steps as argued above. Moreover, using Gong's differential interferometer for measuring the cross-section as taught by Borisov et al. provides a relative distance between a location inside the crater and the cross-sectional surface of the sample portion and not the surface of the sample. Accordingly, claims 40 and 50, which depend from believed allowable claims 37 and 43, are also believed allowable.

Claims 42, 47 and 52 are rejected under 35 U.S.C. 103(a) as being unpatentable over Borisov et al. (Spectrochimica acta) in view of Swanson et al. (US Patent 5,321,501).

Regarding dependent claim 47, Applicant respectfully submits that the method for compositional analysis as defined by the limitations of dependent claim 40 is not obvious in light of the teachings of Borisov et al. and Swanson et al. Replacing the interferometer of Borisov et al. with the scanning interferometer of Swanson et al. does not result in ***in***

situ depth measurement of the ablation crater, as argued above. The method defined by the limitations of claim 47 is highly advantageous for providing fast ***in situ*** measurements of the depth profile of the ablation crater enabling the determination of the depth resolution of the compositional depth profile. However, this information is only useful when obtained through ***in situ*** measurement. Furthermore, the ***in situ*** measurement of the depth profile of the ablation crater enables tailoring of the radial distribution of energy in the laser beam to produce a crater with flat bottom and steep walls in order to ensure good depth resolution of the compositional depth profile. Accordingly, claim 47, which depends from believed allowable claim 43, is also believed allowable.

Regarding dependent claims 42 and 52, Applicant discloses and claims a method and a corresponding apparatus for compositional analysis defined by the limitation that the short coherence light propagates at an angle to the direction of the laser radiation. In the embodiment defined by the limitations of claims 42 and 52, the need for a dichroic plate to superimpose the two beams is eliminated by having the short coherence light propagating at an angle to the direction of the laser radiation. However, since the bottom surface of the ablation crater is substantially normal to the laser beam, the short coherence light is oriented at an angle to the bottom surface. Therefore, the mathematics involved in the depth calculations is more complex in this case, not simpler as suggested by the examiner. Having the short coherence light propagating at an angle to the direction of the laser radiation as defined by the limitations of claims 42 and 52 substantially simplifies the optical system for enabling ***in situ*** depth measurement, while the additional data processing does not require substantially more processing time. Accordingly, claims 42 and 52, which depend from believed allowable claims 38 and 43, are also believed allowable.

Applicant's representative, Mr. Gordon Freedman, tried to arrange a telephone interview with the examiner but didn't receive any response. If there are any issues arising out of the instant response, Mr. Freedman would appreciate the examiner contacting him to clarify or

deal with those outstanding issues.

A Petition for Extension of Time is filed concurrently with this response.

Please charge any additional fees required or credit any overpayment to Deposit Account No. 50-1142.

Applicant requests favourable reconsideration of the application.

Respectfully,

G Fre

Gordon Freedman, Reg. No. 41,553

Freedman and Associates
117 Centrepointe Drive, Suite 350
Nepean, Ontario
K2G 5X3 Canada

Tel (613) 274-7272
Fax (613) 274-7414
Email: info@ipatent4u.com

GF/sah